Urban Forestry & Urban Greening 86 (2023) 127983

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Original article

How perceived sensory dimensions of urban green spaces affect cultural ecosystem benefits: A study on Haizhu Wetland Park, China

Mengyun CHEN [a], Guangsi LIN [a,b,*]

[a] State Key Laboratory of Subtropical Building Science, Department of Landscape Architecture, School of Architecture, South China University of Technology, Guangzhou, 510641, China
[b] Guangzhou Municipal Key Laboratory of Landscape Architecture, South China University of Technology, Guangzhou, 510641, China

ARTICLE INFO

Handling Editor: Dr Cecil Konijnendijk van den Bosch

Keywords:
Cultural Ecosystem Services (CES)
Cultural Ecosystem benefit (CEB)
Human well-being
Landscape perception
Perceived Sensory Dimension (PSD)
Public participation GIS (PPGIS)

ABSTRACT

Research exploring the relationship between human well-being and ecosystem functions by assessing cultural ecosystem benefits (CEBs) is a crucial and emerging field. However, quantifying CEB is challenging due to the lack of a uniform measurement scale. In addition, it is crucial to understand the factors that influence CEBs to enhance ecosystem functions and contribute to human well-being. While physical landscape features have been investigated, there is limited evidence supporting the link between perception-based landscape features and CEBs. Therefore, this study aimed to develop a CEBs measurement scale and investigate the impact of perceived sensory dimensions (PSDs) of urban green spaces (UGSs) on CEBs. We conducted a Public Participation GIS-survey (PPGIS) at Guangzhou National Haizhu Wetland Park. 1473 participants took part in our study and evaluated the CEBs provided by urban green spaces (UGSs). Using SPSS statistics and ArcMap tools, we found that PSDs of UGSs are significantly associated with CEB. Additionally, we confirmed that different levels within a PSD influence the levels of CEBs gained from UGSs. Our results indicate that creating serene, open, and natural UGSs is more effective than incorporating numerous cultural elements. In conclusion, this study introduces PSDs into the framework of CEB, which landscape architects can use to shape the specific environmental characteristics of UGSs and provide the CEBs required to support the well-being of urban populations.

1. Introduction

Urban green spaces (UGSs) have positive contributions to human well-being (Reyes et al., 2021) in terms of air purification, physical health promotion (Jabbar et al., 2022), stress relief (Dzhambov et al., 2018), attention restoration (Meyer-Grandbastien et al., 2020), and social cohesion (Collins et al., 2022; Lopez et al., 2021). However, rapid urbanization has led to the majority of UGSs being converted to more economically advantageous land uses (Dahiya, 2012), potentially limiting urban residents' access to nature and reducing the well-being benefits they derive from it (Franco et al., 2017; Reyes et al., 2021). To ensure that the well-being of urban residents is not compromised by unjustified competition for land, sufficient evidence is required to establish that the benefits of human well-being from UGSs are comparable to those of other land uses.

In this context, the ecosystem services (ES) assessment framework is integrated into the planning and design of UGSs systems, providing a foundation for UGSs maintenance (Egoh et al., 2008). Among the ecosystem services, cultural ecosystem services (CES) have been identified as highly valued for supporting human well-being and enhancing the quality of life for residents (Klain et al., 2014). In particular, CES are often associated with recreational activities, providing opportunities for residents to engage with nature and improve their physical and mental health, and are assumed to serve as "gateway" ES for linking individuals to UGSs (Andersson et al., 2015). Despite significant conceptual and framework improvements in CES(Chan et al., 2012; Church et al., 2021; Haines-Young & Potschin, 2013; MEA, 2005), conceptual vagueness and methodological challenges limit the incorporation of CES into ES assessment frameworks to aid management and decision-making (Blicharska et al., 2017, Grêt-Regamey et al., 2017).

One of the most common limitations of CES is the conflation of services and benefits (Chan et al.,2012; Fish et al., 2016). The Millennium Assessment's definition of CES describes it as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience (MEA, 2005).” However, this definition has been criticized for two main

* Correspondence to: School of Architecture, South China University of Technology, Guangzhou 510641, China.
E-mail address: asilin@126.com (G. LIN).

https://doi.org/10.1016/j.ufug.2023.127983
Received 23 October 2022; Received in revised form 20 March 2023; Accepted 31 May 2023
Available online 7 June 2023

reasons. Firstly, CES assessments often focus solely on the immaterial benefits, such as the feeling of relaxation, without considering the biophysical processes that support these benefits (Blicharska et al., 2017; Bryce et al., 2016; La Rosa et al., 2016). Secondly, the distinction between services and benefits is critical to understanding how benefits are generated, and erasing this distinction could make it difficult to identify their source and influencing factors (Chan et al., 2012; Fish, Church, & Winter, 2016). As a result, CES's value could be undermined by its vague definition, and translating research findings into practical applications to improve human well-being could be a challenge (Bryce et al., 2016; Cheng et al., 2021; Nowak-Olejnik et al., 2022).

In order to narrow the definition gap, the framework proposed by UK NEA (Fish et al., 2016) separates CES and cultural ecosystem benefits (CEBs) clearly. According to the framework, CES refer to the environmental spaces and practices that are ecological processes contributing to human well-being. However, CEBs represent the dimensions of well-being, such as identity, experience, and capability, that are obtained from CES (Bryce et al., 2016; Fish et al., 2016). By differentiating CES from CEB, researchers can analyze the potential of UGSs to provide CES by studying the environmental space and activities within it (Fish et al., 2016). Additionally, gathering preferences from respondents allows researchers to evaluate the benefits derived from UGSs. More importantly, it provides a clear path to where the benefits are formed. This allows designers and managers to optimize the physical environmental space and activities within these spaces to maximize the benefits for individuals. Overall, the distinction between CES and CEB improves the clarity of their definitions and facilitates better analysis and management of ecosystems for human well-being.

Methodological limitations also restrict the research and implications of CES. Surveys on preferences are currently the mainstream methods for measuring CES and CSB. In particular, public participation GIS (PPGIS) has been increasingly used in relevant studies in recent years. This method involves survey respondents identifying the geographic location of a particular activity and completing questionnaires to assess the benefits obtained from their interaction with the site (Brown et al., 2014; Brown & Kyttä, 2014). This allows researchers to correlate specific geographic spaces with people's perceived benefits, providing insight into the influence of environmental dimensions on CEBs. However, low response rates have been a barrier to these studies. According to Brown (2013), the average response rate of web-based PPGIS studies is 13%. Additionally, the mapped physical location strongly depends on respondents' familiarity with the region. The method has been criticized for its lack of geographical precision, which might result in a lower model fit of the variables (Brown and Kyttä, 2014; Pocewicz et al., 2012). Furthermore, current PPGIS research mainly focuses on the impact of single physical environment features on CEBs, such as land use/land cover (Schirpke, 2017), topography (Brown, 2013), and landscape elements (Xin et al., 2020). It is important to recognize that people's evaluation of environmental characteristics in real life does not depend on a single physical dimension (Dade et al., 2020). Instead, all cultural services require the engagement of human senses and brain activity to interpret information offered by ecosystem components and structure (Cai et al., 2022). By correlating quantifiable physical attributes of the landscape with perception-based landscape features, researchers can gain insights into what drives people's assessment of ecosystem benefits (Zoeller et al., 2022). This understanding of the various interconnected aspects that shape our experience and perception of nature may add to the conversation on sustainability (Folke et al., 2011). While the contribution of physical landscape features to the supply of CES and CEB is well researched, more evidence is needed to understand the correlation between perception of landscape features and CEB.

As a result, in this research, we identify perceived sensory dimensions that have an impact on CEBs. These perceived sensory dimensions add to the UK NEA theoretical framework (Fig. 1) and may help exploring how perceived sensory qualities of urban green spaces impact cultural environment benefits. We focus on the following specific questions.

(1) What are the cultural ecosystem benefits that people can obtain from urban green spaces?
(2) Is there a correlation between the perceived sensory dimensions (PSDs) of UGSs and the cultural ecosystem benefits? If yes, which specific PSDs are associated with these benefits?
(3) How do the different PSDs and their perceived levels influence cultural ecosystem benefits?

2. Method

Fig. 2 outlines the practice-oriented workflow developed for our research. Initially, self-reported data from respondents with geospatial coordinates was collected using the PPGIS platform. This data included information on CEBs, PSDs, and socio-demographic characteristics of the respondents. ArcMap platform was then used to visualize the data spatially, and hot-spot analysis was applied to identify significant spatial patterns. To address the research questions, various analyses were conducted on the collected data. These included a reliability and validity test to assess response consistency and validity, correlation ratio analysis to examine the relationship between CEBs and PSDs, and Kruskal-Wallis H test to determine if there were significant differences in perception among different levels of the same PSD on the level of CEBs.

2.1. Study area

The study was performed in Haizhu National Wetland Park, located in the downtown Guangzhou area in the Guangdong province in South China. As a typical green space impacted by land competition during urbanization, its size diminished from 40 km^2 to only 11 km^2 today. Before it was declared a national wetland park in 2015, it was an ancient orchard with a history dating back almost 400 years. The orchard was composed of ponds, rivers, and subtropical fruit forests, organized by a dike-pond system, representing the most characteristic landscape of the Pearl River Delta. Most of the traditional dike-pond system was reconstructed to various types of wetland systems, including rice paddies, swamps, and mangroves. Additionally, a bird observatory, camping areas, greenways along the lake, and other leisure opportunities were added to the park, making it a popular destination for nature engagement and recreation.

Since a large part of the wetland park's purpose is ecological conservation, it is not easily accessible to the public. Given that CEBs arise from the interaction between people and nature, we conducted this study only in the wetland area open to the public, which is roughly one-half of the park including ShangChong orchard park, Haizhuhu park, Wetland phaseIand Wetland phase II (Fig. 3).

2.2. Questionnaire

This study employed an on-site survey-based approach to gather data on human-environment interactions. The data collection process involved three distinct sections: the Cultural Ecosystem Benefits Scale (Section 2.2.1), the Perceived Sensory Dimension Scale (Section 2.2.2), and socio-demographic questions (Section 2.2.3), which are described in detail in the following sections.

2.2.1. Cultural ecosystem benefits scale

In this section, respondents were asked to answer the question, "To what extent do you agree to the following descriptions about your feelings after the activities here." Participants responded using a 5-point Likert scale (0 = "Strongly disagree," 1 = "Disagree," 2 = "Neutral," 3 = "Agree," and 4 = "Strongly agree").

The initial survey for this section included 16 questions, which covered the three dimensions of CEB identified by Fish et al. (2016):

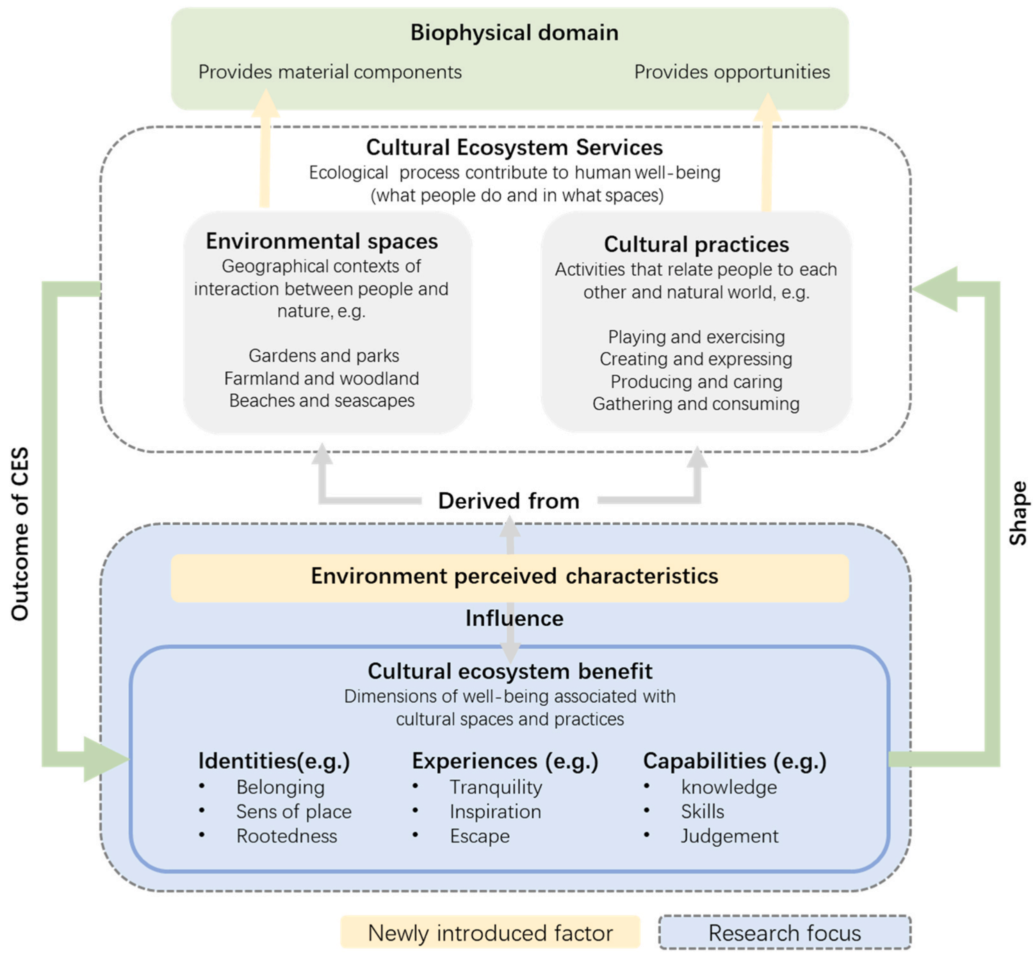

Fig. 1. The theoretical framework of our research (Adapted from Fish.et al. (2016), supplemented by perceived sensory dimensions).

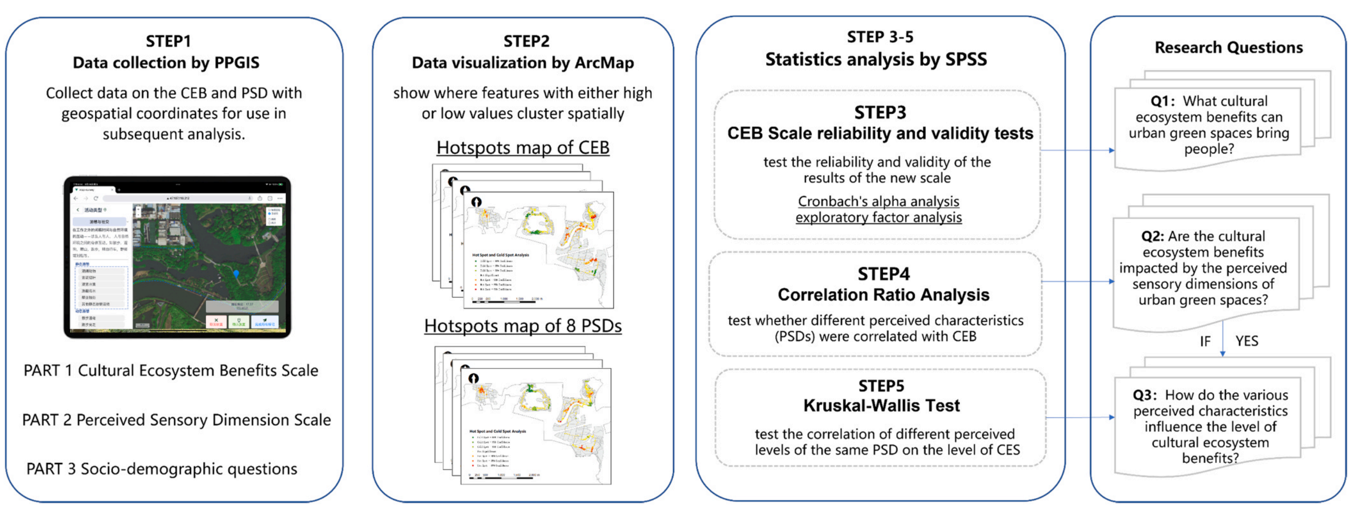

Fig. 2. Practice-oriented workflow for the research.

identity, experience, and capability. To develop the scales, we first analyzed the definitions of the dimensions and identified classical scales that were available. Based on this analysis, we generated initial scales that combined the definitions and classical scales (Table 1), which were then pre-tested to create the final scale.

The "identity" dimension was defined as the role of ecosystems in the process of place identification and affiliation (Fish et al., 2016). We used the place attachment scale from Kyle et al. (2005) to capture the benefits of emotional engagement, self-integration, social bonding, and place identity, resulting in four questions.

The "experience" dimension was defined as the mental and physical benefits of contact with ecosystems (Fish et al., 2016). To measure these benefits, we combined the Restoration Outcome Scale (Korpela et al., 2008) and the Short-Form Six-Dimension (SF-6D) health index (Brazier et al., 2002) to create eight questions.

The "capability" dimension was defined as the role of ecological

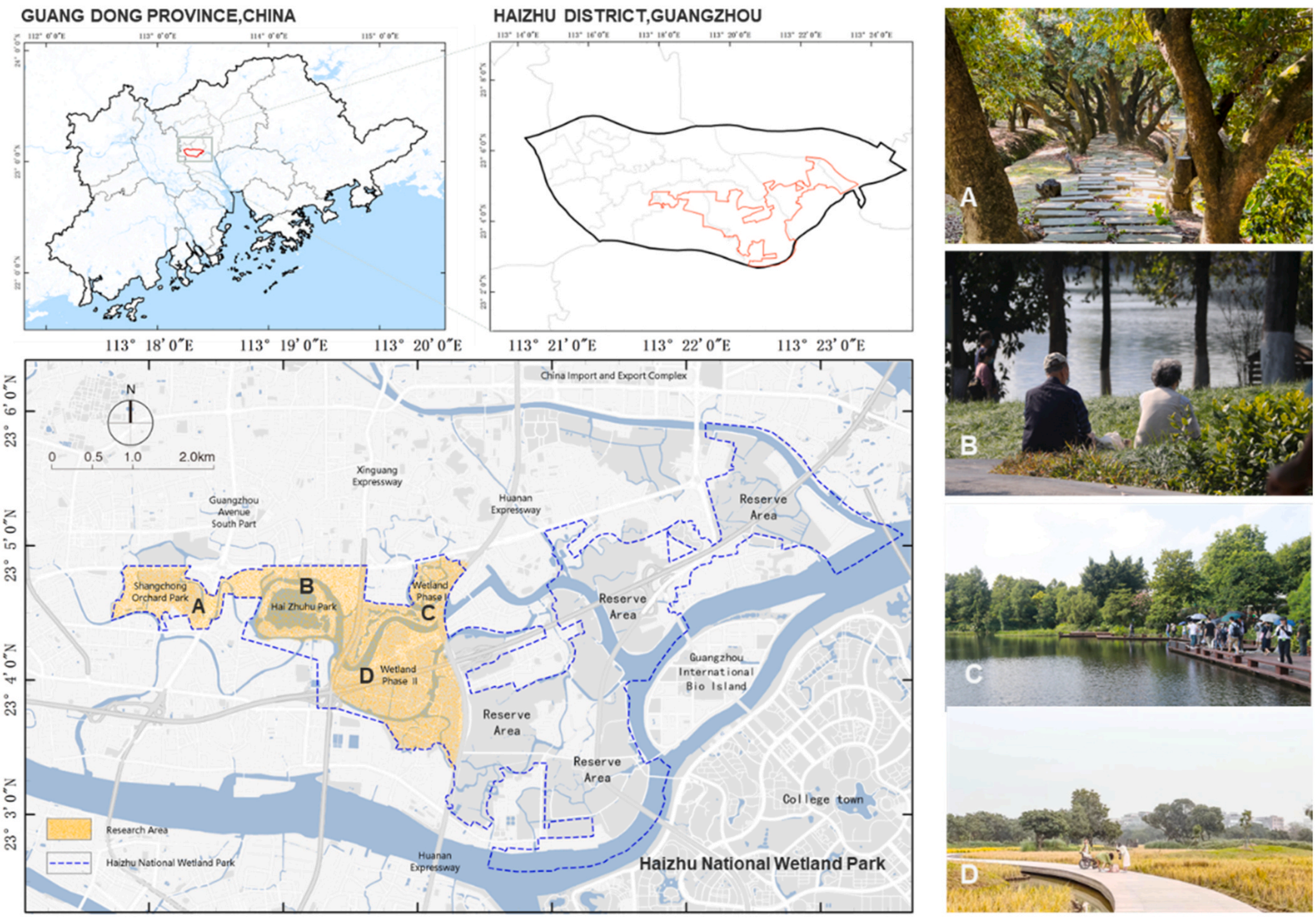

Fig. 3. Research area (A: ShangChong orchard park, B: Haizhuhu park, C:Wetland phaseI and D:Wetland phase II).

phenomena in shaping individual and social capacities to understand and do things (Fish et al., 2016). Because there were few classical scales suitable for this dimension, we developed questions based solely on the definition. These questions covered topics such as learning about nature, developing knowledge and abilities, finding inspiration, and increasing income.

To evaluate the quality of the pilot-tested questionnaire, we employed easy sampling to gather 180 responses and conducted a comprehensive assessment of reliability and validity of initial scale using Cronbach's alpha analysis and exploratory factor analysis, respectively. We initially calculated the reliability coefficient for each construct's elements and dimensions and set the usual lower bound for Cronbach's alpha at 0.7. We then eliminated items that did not contribute significantly to reliability. Our analysis revealed that the inclusion of “income” led to a decrease in the overall scale and capability dimension reliability. Additionally, exploratory factor analysis showed that including "income" resulted in a four-dimensional scale, with “income” loaded onto a single dimension. However, removing “income” from the scale resulted in high loadings on all items in their respective components. Consequently, we established a final 15-item CEB scale by removing “income” (more detail in Appendix A.1).

To illustrate the relationship among each benefit, sub-dimension of CEB, and the total CEBs, we can express it as follows:

$$CEB_{total} = \sum_{i=1}^{15} b_i$$

$$CEB_{identity} = \sum_{i=1}^{4} b_i$$

$$CEB_{experience} = \sum_{i=5}^{12} b_i$$

$$CEB_{capability} = \sum_{i=13}^{15} b_i$$

2.2.2. Perceived sensory dimensions

To capture the key dimensions of perceived characteristics of urban green spaces (UGSs), the survey employed the Perceived Sensory Dimensions (PSDs) scale developed by Grahn (Stoltz and Grahn, 2021). The survey focused on eight perceived characters: “Natural”, “Cultural”, “Social”, “Serene”, “Diverse”, “Cohesive”, “Open”, and “Sheltered”. Additional information on the survey choices is available in Appendix A.2. This instrument has undergone development through four generations (Grahn, 1991; Gyllin, 2005; Grahn and Stigsdotter, 2010; Adevi and Grahn, 2012) and has demonstrated good reliability (Memari et al., 2021) in over 100 empirical studies conducted in countries such as China (Chen et al., 2018), Sweden (Grahn and Stigsdotter., 2010), and Canada (Lockwood., 2017). As a fairly mature tool for analyzing environmental perception features, the survey asked respondents to indicate the extent to which they agreed with the descriptions of the site characteristics they were currently at using a 5-point Likert scale (0 = "Strongly disagree," 1 = "Disagree," 2 = "Neutral," 3 = "Agree," and 4 = "Strongly agree").

2.2.3. Socio-demographic questions

Towards the end of the survey, respondents were asked to provide socio-demographic information, such as their gender, age, place of

Table 1
Indicators statements used to assess CEB.

Sub-dimensions	Abbr.	Indicator	Indicator statement	Reference/Derive from
Identity	b1	Place identity	It improves my appreciation for the city/community	PAS; NEA
	b2	Sense of place	It improves my sense of belonging in the city/community	PAS; NEA
	b3	Place dependence	It has become a vital part of my daily routines	PAS; NEA
	b4	Social bonding	It improves my connection with my family/friends/loved ones	PAS; NEA
Experience	b5	Relaxation and calmness	I feel more relaxed	SF-6D; NEA; Pre-investigation
	b6		I feel happier	ROS; NEA; Pre-investigation
	b7		I feel more energy	SF-6D; NEA
	b8	Attention restoration	I feel more focused	ROS; NEA
	b9	Clearing one's thoughts	It helps me clear my thoughts	ROS; NEA
	b10		It helps me leave my worries for a while	ROS; NEA
	b11	Social connection	I feel less lonely	SF-6D; NEA
	b12	Physical health	I feel physically healthier	SF-6D; NEA
Capability	b13	Knowledge	It helps me learn more about nature	NEA
	b14	Skills	It helps me in acquiring some abilities/skills	NEA
	b15	Inspiration	It inspires me	NEA
	b16	Income	It helps me to increase my income and standard of living	NEA; Pre-investigation

PAS: Place attachment scale; NEA: UK National Ecosystem Assessment;
SF-6D: Short-Form Six-Dimension health index; ROS: restoration outcomes scale;

residence, employment status, income level, educational background, relationship with the park, frequency of park visits, and familiarity with the park. More information on these questions can be found in Appendix A.3.

2.3. Data collection

For data collection, the study team created, pre-tested, and developed an internet-based PPGIS website in Chinese (http://47.107.118.212/mapsurvey/)(more details in Appendix B). The study website includes an online map of the site, a cultural practice selection box, and a text-based questionnaire with three components: the Cultural Ecosystem Benefits Scale, the Perceived Sensory Dimension Scale, and socio-demographic questions. From January 7, 2022, to April 13, 2022, a group of 15 landscape architecture students conducted data collection on site using an electronic questionnaire on iPad. Below we describe the steps in detail.

1) 15 landscape architecture students used random park sampling to invite visitors to fill out the questionnaire on the iPad provided by the study team.
2) After accepting the invitation, the visitor will join the study with the assistance of the investigator. The agreement to be informed was included in the first section of the website. Clicking on it would bring up a map interface separated into two sections. The activity panel is located on the left side, and a Gaode map interface is seen on the right side. Two types of maps were provided: an orthophoto-map and a street map. Respondents could zoom in and out.
3) In this stage, participants were directed to choose the activity bottom from the activity panel that corresponded to their activity type and drag it to the location on the map according to their location. Furthermore, using a handy global positioning system, the researcher would aid the responder in correcting specific geographic location. Only at a zoom level of 17.5 (or about 1:2500) and above were respondents permitted to begin answering the questionnaire.
4) After completing the mapping task (placing markers), participants were directed to a new page and asked to complete a series of text-based survey questions according to the space and activity they mapped. The questionnaire included 32 questions, including 8 on PSDs, 15 on CEB, and 9 on socio-demographic characteristics.

2.4. Data analysis

A total of 1473 responses were collected, which included data on CEBs, PSDs, and socio-demographic characteristics of the respondents. The data was stored in a MySQL Heatwave database and later downloaded into Excel for processing. Statistical analysis was conducted using SPSS Statistics, while ArcMap was used for spatial analysis.

2.4.1. Reliability and validity of the CEB scale

We used both Cronbach's alpha analysis and exploratory factor analysis to ensure the reliability and validity of our newly created CEB scale. Our standard lower bound for Cronbach's alpha was set at 0.7, indicating that the scale is reliable if it scored above this threshold. To investigate the relationship between different items and test whether the construct measures align with our hypothesis structure, we performed exploratory factor analysis using SAS Varimax orthogonal rotation.

2.4.2. The relationships between CEB and PSDs

In order to examine the relationship between the continuous variables of CEBs and the ordinal variables representing PSDs, the correlation ratio was used as a statistical method in this study. The significance of the correlation was tested at a p-value threshold of less than 0.05. The strength of the correlation was quantified and reported using the effect sizes (Partial Eta Squared, ETA^2), which categorizes correlations as weak ($\eta^2 < 0.06$), moderate ($0.06 \leq \eta^2 < 0.14$), or high ($0.14 \leq \eta^2$). If the analysis indicated that there was a correlation between the two variables but it was weak, this was typically considered not statistically significant and therefore not included in further analysis.

2.4.3. The effects of PSD on CEB

To investigate the impact of different levels of perceived PSDs on CEBs, we used the Kruskal-Wallis H test in our study. This nonparametric method is suitable for comparing more than two independent groups without assuming a normal distribution. If the null hypothesis of the Kruskal-Wallis H test, which posits that there is no significant difference in the effect of various perceived PSD levels on CEBs, was rejected, we used the Dunn-Bonferroni method to perform pairwise comparisons. This post hoc test corrected for multiple comparisons and enabled us to pinpoint specific levels within the same PSD that had an impact on CEB. In determining statistical significance, we set a threshold of $p < 0.05$. Differences that met this threshold were considered statistically significant.

2.4.4. Hotspot analysis

In order to visualize the hotspots and coldspots of mapped CEBs and PSDs, we used the HotSpot Analysis tool (Getis-Ord Gi*) in ArcMap version 10.8.1. This tool calculates the Getis-Ord Gi* statistic for each feature in a dataset, which allows us to identify where features with high or low values cluster spatially. The resulting z-scores and p-values provide valuable insights into the intensity of clustering. A larger z-score for statistically significant positive z-scores indicates a more intense clustering of high values (hotspot), while a smaller z-score for statistically significant negative z-scores indicates a more intense clustering of low values (coldspot).

3. Results

3.1. Respondent characteristics

A total of 1473 surveys were carried out, out of which 21 were identified as outliers during the data pre-processing stage in SPSS. Outliers were defined as any data value that falls outside the range of 1.5 times the interquartile range (IQR) from the upper or lower quartiles. These outliers were excluded from the quantitative analysis, leaving us with 1452 questions to be included in the statistical analysis.

In terms of demographics, 58.1% of the respondents in our study were female. The majority of the respondents fell between the ages of 19 and 49 years old (70%), and over half of respondents held a bachelor's degree (54.3%). In terms of occupation, 53.2% were employed, 21.6% were students, 17.6% were retired, and 9.5% were either unemployed or in other circumstances. The highest income group (annual income > ¥80,000) and the lowest income group (< ¥16,000) accounted for a similar proportion of respondents, contributing 30.2% and 29%, respectively. Approximately half of the respondents (50.4%) reported visiting the park at least once a month, and nearly half of them reported being familiar with the park.

3.2. Reliability and validity analysis for 15-item CEB scale

The reliability and validity of the 15-item CEB scale used in this study were assessed since it was a newly created scale combining adapted classic scales and the CEB definition of NEA.

With regard to the reliability of the CEB scale, the results showed that overall Cronbach's alpha of the scale was found to be 0.895, which indicates high internal consistency. Additionally, the Cronbach's alpha for each dimension of the scale was found to be 0.725 (identity), 0.850 (experience), and 0.733 (capability), indicating high consistency within each dimension. No item elimination could further increase the overall scale reliability, indicating that all 15 items are essential components of the scale.

To assess the validity of the CEB scale, an exploratory factor analysis was conducted. Principal Components Analysis with varimax rotation was performed on all 15 items, and Bartlett's Test of Sphericity yielded significant findings ($\chi 2$ (105) = 7856.469; p = 0.001), indicating that the variables were associated. The correlation matrix was adequate for factor analysis, according to the KMO statistic (Kaiser, 1974). A 3-dimension solution was found to be the best fit for the data, with the minimal factor loading condition set to 0.50 and the Kaiser's criterion of eigenvalues higher than 1. The 3 dimensions accounted for 56.038% of the variance in the data, with b5-b8 loaded on dimension 1, b1-b4 loaded on dimension 2, and b13-b15 loaded on dimension 3. Notably, the three factors corresponded to the theoretically established 3-dimensional structure of the CEB scale, demonstrating adequate construct validity.

Overall, the reliability and validity analyses indicated that the 15-item CEB scale is a reliable and valid tool for measuring CEB, and the three dimensions of the scale are essential components.

3.3. Cultural ecosystem benefits provided by the urban green spaces

3.3.1. Perceptions of each cultural ecosystem benefit

Respondents were asked to evaluate their perceptions of 15 CEBs emerging from the interaction of cultural practices and environmental environments. The largest reported benefit was " I feel happier (b6)," (mean value=3.43) accounting for 92.4% (51.38% strongly agreed, and 40.98% agreed with the statement). The other highly valued benefits (mean value > 3.0) were "improves my appreciation for the city/community (b1)," "more energy (b7)," "leave worries for a while (b10)," "feel physically healthier (b12)," and "improves my sense of belonging (b2)". While "acquiring some abilities/skills (b14)," "become a vital part of my daily routines (b3)," "inspiring, (b15)," and " feel less lonely (b11)" were the four lowest perceived benefits with mean values of 2.44, 2.56, 2.58, and 2.93, respectively. Only 18.73% of participants reported obtaining these benefits from the UGSs, particularly in the item of" acquiring some abilities/skills (b14)" (Fig. 4).

3.3.2. Spatial distribution of mapped cultural ecosystem benefits

Overall, maps indicate that the values for CEBs were not distributed randomly, which showed statistically significant spatial clustering. Each CEB has its own distribution pattern (refer to Appendix C), while the total CEBs and 3 sub-dimensional CEBs showed similar aggregation trends (Fig. 5). The locations with the highest perceived benefits, marked by the darkest red color, were found in the northern section of the wetland phase I, for both the total CEBs and the sub-dimensions Experienced and Capability. The locations exhibiting the lowest perceived benefits, identifiable by the darkest green color, are situated on the north riverside of Haizhuhu Park and Wetland phase I, as well as the middle section of Wetland phase II, specifically an underwood platform.

3.4. Perceived sensory dimensions of the urban green spaces

3.4.1. Perceptions on each perceived sensory dimension

The findings describe the 8 PSDs of the park observed by the respondents (Fig. 6). With an average value of 3.4, "open" was the highest perceived feature. Around 88.34% of respondents agreed with the statement "the site where I am located is an open space" (53.99%

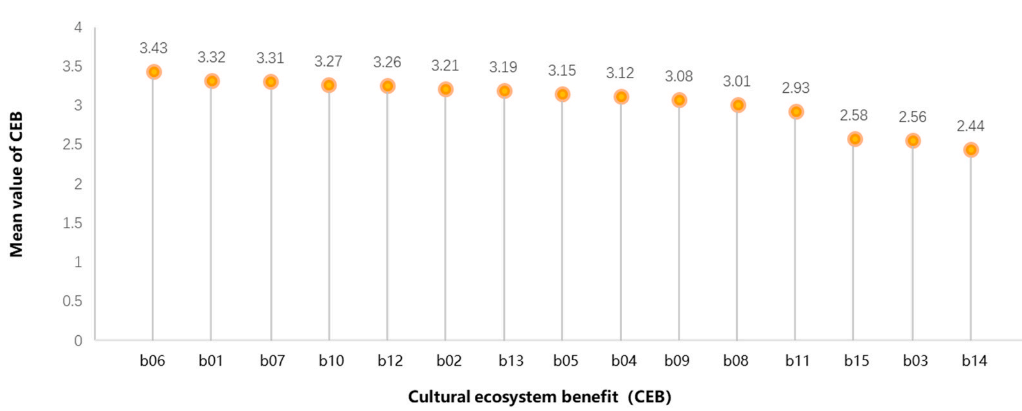

Fig. 4. Average values of CEB from 1452 Responses.

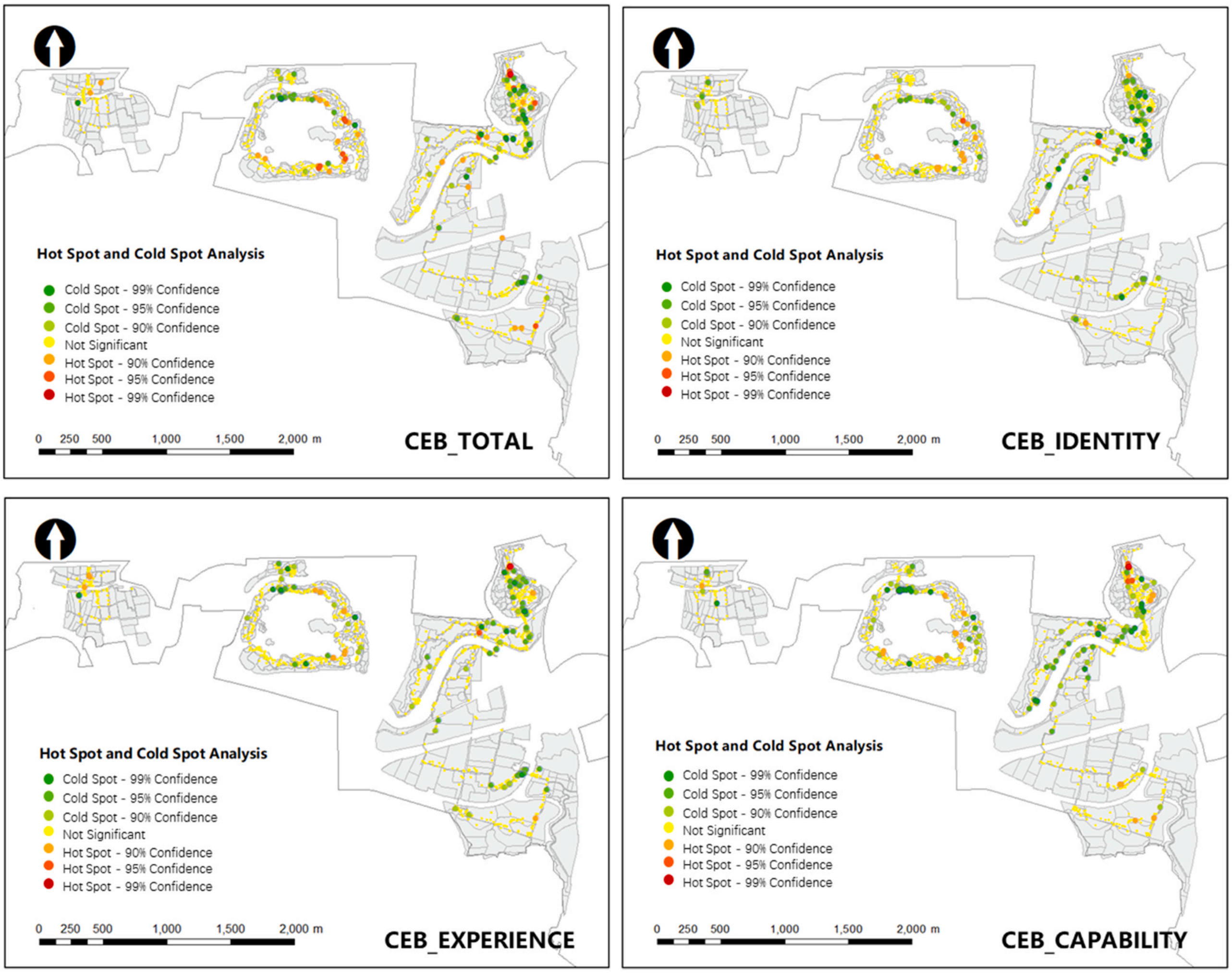

Fig. 5. Hotspots map of total CEBs and 3 sub-dimensions of CEB.

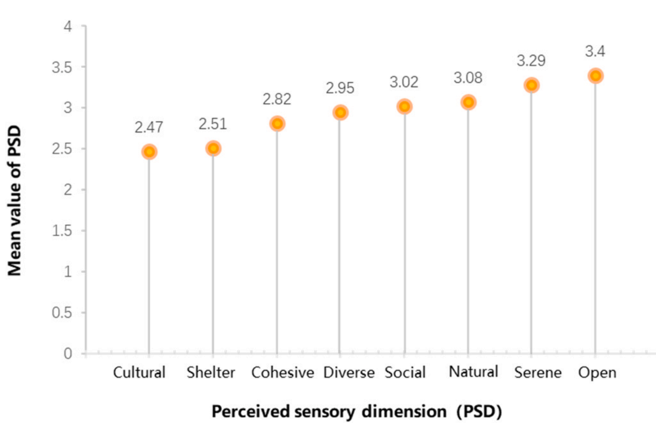

Fig. 6. Average value and probability distribution of different levels of CEBs from 1452 Responses.

strongly agreed and 34.44% agreed). Merely, 0.21% completely disagreed with this statement. Similarly, "Serene" was a strongly perceived dimension of the park, with 83.61% of respondents completely agreeing with "the space I am in is serene". With an average value of just 2.47, the "Cultural" feature had the lowest degree of perception. Merely 15.84% of respondents believed that "the environment I am in is a cultural space".

3.4.2. Spatial distribution of perceived sensory dimensions

The spatial distribution of PSDs demonstrated a clustering trend, with each of the 8 PSDs having its own distribution pattern (Appendix D). The coldspots for "Cultural", "Diverse", and "Open" dimensions were found in the northern part of the Shangchong orchard Park, while the coldspots for "Natural," "Serene," and "Sheltered" were concentrated in the square along the lake in the northern part of Haizhuhu Park. The hotspots for both "Natural" and "Sheltered" were found in the northern part of the Shangchong orchard Park. For "Sheltered," there were also hotspots in the area along the river in Wetland phase I. Interestingly, the distribution of "Social" and "Cohesive" showed some opposite trends. The southern area of Haizhuhu Park was a cold spot for "Social" but a hotspot for "Cohesive," while the cherry blossom forest in the middle of Wetland phase II was a cold spot for "Cohesive" but a hotspot for "Social."

3.5. Relationship between different PSDs and CEBs

The results of the correlation ratio analysis showed that all PSDs were correlated with total CEBs, except for "Cultural" (Table 2). The strongest correlation was observed between "Diverse" and total CEBs ($p = 0.00 < 0.05$, $ETA^2 = 0.161 > 0.14$). Similarly, the level of "Natural" was highly correlated with the total CEBs ($p = 0.00 < 0.05$, $ETA^2 = 0.155 > 0.14$). The PSDs "Serene," "Open," "Sheltered," "Cohesive," and "Social" were moderately correlated with the total CEBs value, in descending order of effect sizes.

Table 2
Effect Size for Correlations between PSDs and total CEBs.

	Diverse Total CEBs	Natural Total CEBs	Serene Total CEBs	Open Total CEBs	Sheltered Total CEBs	Cohesive Total CEBs	Social Total CEBs	Cultural CEBs	Total CEBs
ETA^2	0.161[c]	0.155[c]	0.116[b]	0.104[b]	0.093[b]	0.09[b]	0.074[b]	0.019[a]	

[a] Weak correlation:
[b] Moderate correlation:
[c] High correlation:

Table 3
Effect Size for Correlations between PSDs and the sub-dimensions of CEB.

Identity (b1-b4)		Experience (b5-b12)		Capability (b13-b15)	
PSD	ETA^2	PSD	ETA^2	PSD	ETA^2
Natural	0.141[c]	Diverse	0.125[b]	Diverse	0.076[b]
Diverse	0.129[b]	Natural	0.122[b]	Natural	0.054[a]
Sheltered	0.091[b]	Serene	0.118[b]	Cohesive	0.038[a]
Social	0.090[b]	Sheltered	0.089[b]	Open	0.036[a]
Open	0.090[b]	Cohesive	0.087[b]	Serene	0.023[a]
Serene	0.090[b]	Open	0.086[b]	Social	0.020[a]
Cohesive	0.052[a]	Social	0.057[a]	Cultural	0.016[a]
Cultural	0.014[a]	Cultural	0.018[a]	Sheltered	0.015[a]

[a] Weak correlation:
[b] Moderate correlation:
[c] High correlation:

The correlation analysis between the PSDs and sub-dimensions of CEBs revealed that only the “Natural” dimension had a high correlation with the sub-dimensions of CEBs. However, many other PSDs showed moderate correlations with the sub-dimensions of CEBs. Specifically, “Natural” and “Diverse” had the higher correlations with the benefits of the “identity” dimension ($ETA^2 > 0.1$). In the “experience” dimension, the three PSDs with the highest correlations were “Diverse,” “Natural,” and “Serene.” For the “capability” dimension, only “Diverse” showed a significant correlation (Table 3).

Based on the results reported by the effect size for correlation ratio analysis (Appendix E), we counted the number of PSDs associated with each benefit (Table 4). We considered a benefit to be highly correlated with PSDs if it has more PSDs associated with it than the average number. Our analysis revealed that “feel happier (b6)” is the benefit that has the highest number of correlations with PSDs. All eight PSDs, excepting for the "Cultural" dimension, are correlated with it. When we ranked the benefits in descending order based on the number of PSDs associated with them, we found that the benefits highly correlated with PSDs were “feel more energy (b7),” “improves my appreciation for the city/community (b1),” “improves my connection with my family/friends/loved ones (b4),” “feel more focused (b8),” and “"feel physically healthier (b12).”

When examined in terms of the number of CEBs correlated with PSDs (Table 5) based on the effect size for correlation ratio analysis (Appendix E), the PSD with the highest number of correlations with specific benefits was “Natural”. This dimension had moderate correlations with 10 benefits. The “Diverse” dimension was the next most highly correlated PSD, with 9 moderate correlations with the benefits. In contrast, the “Cohesive” and “Social” dimensions only showed correlations with two benefits each.

3.6. Effects of PSD on CEB

We performed a Kruskal-Wallis H test to examine the effects of the PSD levels on total CEBs. The results indicate that the perceived level of same PSD significantly affects the level of CEB (Table 6). Fig. 7 shows the pairwise comparison results for different perceived levels of each PSD. In this figure, each pentagon represents a PSD, and the numbers assigned to the vertices indicate different perceptual levels within the PSD. The yellow lines connecting two vertices indicate a discernible difference in CEB between those two levels of the PSD, while the gray dashed lines signify no perceivable difference in CEB between those two levels. Specifically, our analysis revealed that the total CEBs differed significantly between the highest level of PSD (level = 4) and the other levels of PSD (level = 0/1/2/3). The PSDs “Natural,” “Diverse,” and “Sheltered” showed significant differences in total CEBs between the highest level of PSD and all other levels of PSD. For “Serene,” “Social,” “Cohesive,” and “Open,” the results indicated significant differences in total CEBs between the highest level of PSD and all other levels of PSD, except for level 0. Furthermore, for “Natural,” “Diverse,” and “Sheltered,” the results showed significant differences in total CEBs between level 3 and levels 1 and 2. Finally, the results for "Cohesive" and "Diverse" revealed significant differences in total CEBs between level 0 and level 3. (More details data in Appendix F).

4. Discussion

4.1. A scale for measuring CEB of UGSs based on the NEA framework

Our research study proposes a 15-item CEB Scale at the UGS scale based on the framework of UK NEA (Fish et al., 2016). This framework has been used in previous research but with a focus on regional scales such as marine sites (Bryce et al., 2016), coastal areas (Clarke et al., 2021; Michaelis et al., 2021; Ramirez Aranda et al., 2023), national nature reserves (Fish et al., 2016), and forests (Baumeister et al., 2020). In contrast, our study is the first, as far as we know, to independently measure the CEBs of UGSs from the identity, experience, and capability dimensions concurrently at the site scale. The CEB Scale adds to the existing scales of applied research on this theoretical framework.

Table 4
Number of PSDs correlated with the CEBs.

CEBs	Identity (b1-b4)					Experience (b5-b12)							Capability (b13-b15)			Average number
	b1	b2	b3	b4	b5	b6	b7	b8	b9	b10	b11	b12	b13	b14	b15	
Number of PSD correlated with the CEBs	4	4	1	4	1	7	5	3	3	0	0	3	2	1	0	2.33

Table 5
Number of CEBs correlated with PSDs.

PSDs	Natural	Diverse	Serene	Open	Sheltered	Cohesive	Social	Cultural
Number of CEBs correlated with PSD	10	9	6	5	3	2	2	0

Table 6
Kruskal–Wallis H test results among 8 PSDs.

PSD	Null Hypothesis	Test	Sig.	Decision
Natural	The distribution of Total CEBs is the same across levels of PSD1-natural	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
Serene	The distribution of Total CEBs is the same across levels of PSD3- Serene		0.000	Reject the null hypothesis.
Social	The distribution of Total CEBs is the same across levels of PSD4- Social		0.000	Reject the null hypothesis.
Cohesive	The distribution of Total CEBs is the same across levels of PSD5- Cohesive		0.000	Reject the null hypothesis.
Diverse	The distribution of Total CEBs is the same across levels of PSD6- Diverse		0.000	Reject the null hypothesis.
Open	The distribution of Total CEBs is the same across levels of PSD7- Open		0.000	Reject the null hypothesis.
Sheltered	The distribution of Total CEBs is the same across levels of PSD8- Sheltered		0.000	Reject the null hypothesis.

The CEB Scale has practical implications for land use decision-making, urban planning, and management. Firstly, Policymakers and planners can imply the CEB Scale to measure the specific CEBs that existing UGSs can provide. Our study has identified the most crucial CEBs, established a clear hierarchy of importance for different benefits, and provided detailed descriptions for each. This approach makes the benefits more identifiable and tangible, which was a limitation in previous studies that failed to capture the complex relationship between individuals and ecosystems (Bieling et al., 2014). As a result, research results in those previous studies were challenging to translate into effective practice (Dickinson & Hobbs, 2017). In contrast, our study considered the full range of benefits, including the more elusive ones such as identity, a sense of place, and the symbolic value of green infrastructure, in the decision-making process for improving UGS, it can contribute to the satisfaction and well-being of visitors (Kenter et al., 2016).

Moreover, the CEB Scale enables more ecologically sound decisions in urban planning processes. With respect to the subdimensions of the scale, particularly the "identity" dimension, decision-makers, planners, and designers are encouraged to evaluate the relational values of ecosystems resulting from human interaction with nature (Baard, 2019), such as a sense of belonging, place attachment, and social bonding. These values were often neglected or oversimplified in previous research (Blicharska et al., 2017; Bryce et al., 2016). Much of the research has focused on instrumental values that are easier to evaluate, such as recreational benefits (He et al., 2016; Inácio et al., 2022; Tian et al., 2023) and aesthetic benefits (Cooper et al., 2016; Huai et al., 2022; Oteros-Rozas et al., 2018; Zhang et al., 2022). The CEB Scale helps to prevent the narrow focus on the instrumental value of ecosystems, which may lead to human-centered utilitarianism (Baard, 2019). By considering the full range of ecosystem benefits, the CEB Scale promotes a holistic understanding of human-nature relationships and encourages sustainable and resilient urban planning solutions that support ecological preservation and enhance the overall well-being of urban residents.

The CEB Scale helps bridge the gap in ecosystem services evaluation, where non-material benefits are often underestimated (Jabbar et al., 2022; La Rosa et al., 2016) leading to unbalanced decision-making (Blicharska et al., 2017; Chan et al., 2012; Kenter et al., 2016). CES are often undervalued due to their unclear definitions and inappropriate economic value evaluating methods(Cooper et al., 2016; Edwards et al., 2016), when they were incorporated into other ESs framework. The CEB Scale clarifies the link between cultural ecosystem services (CES) and cultural ecosystem benefits (CEB) by distinguishing between spaces, practices, and benefits. This distinction helps policymakers and practitioners to better account for the contribution of CES to human well-being in broader ecosystem services evaluations (O'Brien et al., 2017).

4.2. Combining GIS data and questionnaire data for CEB measurement and UGS management

To quantify CEBs and PSDs in our research, we used a five-point Likert scale as in most stated preference surveys. Additionally, to identify the locations where high and low levels of CEBs and PSDs are clustered, we employed hotspot analysis for the data we captured through participatory mapping. It has been shown to be effective in capturing the benefits people gain from specific locations (Alessa et al., 2008; Baumeister et al., 2020; Rall et al., 2017; Sherrouse et al., 2011). Our approach builds upon most previous studies that used the number of marked points as a proxy for the perceived level of CES/CEBs and the density of points in space to represent the intensity of benefits (Brown et al., 2018; Plieninger et al., 2013). Since the number of points only represents the frequency of a benefit being perceived and does not indicate the level of perception (Xu et al., 2020), our research combined

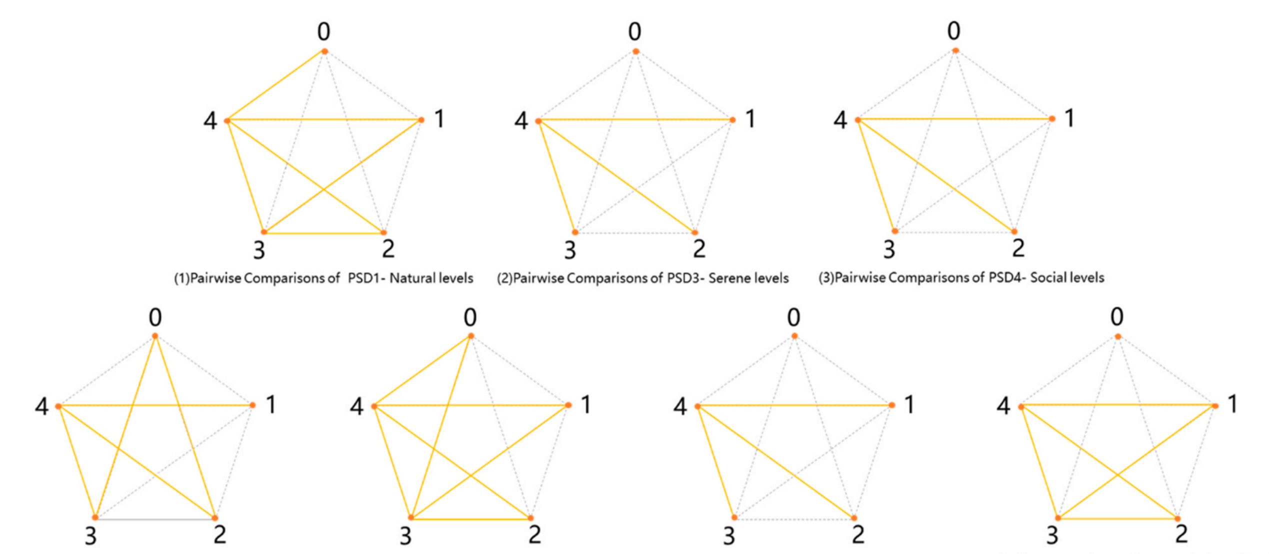

Fig. 7. The results of pairwise comparisons between the different levels of each PSD.

the five-point Likert scale with hotspot analysis to capture hotspots of each CEB and PSD based on the perceived level in the map, resulting in more precise study results. UGSs managers can use detailed visualization data to pinpoint areas with low benefits and increase the benefit level by incorporating spatial elements that promote CEB. This improves the overall CEB of UGSs. Furthermore, using the combinational method for land decision and UGSs planning provides process advantages (Alessa et al., 2008). It can combine expert knowledge with local knowledge to create UGSs management plans for different zone of the UGSs. Plans created only by experts may overlook subjective factors on site, but those incorporating publicly held benefits and input from planners and managers will better reflect the needs and preferences of the users.

Furthermore, our study employed an on-site digital participatory mapping approach that applied GPS devices and researchers' assistance to correct specific geographic locations marked by respondents. This approach significantly improved the geographic accuracy of the study data, which relied on respondents' familiarity with the site in previous studies (Brown et al., 2012; Brown and Kyttä, 2014). In addition, face-to-face communication and researcher assistance on site played a significant role in increasing the response rate of our study. Most visitors were willing to join us on-site, and we observed a higher response rate compared to the mailed approach, which has been known to have low response rates in previous studies (Brown and Kyttä, 2014; De Vries et al., 2013; Pocewicz et al., 2012).

4.3. Implications of PSDs for the CES framework and UGS planning

Based on our examination of the PSDs and CEBs, it is evident that the concept of PSD can serve as a valuable addition to the CES theoretical framework. Our findings extend the existing theory that CEB is a direct outcome of CES (i.e., a specific physical space and activities carried out in it). Because we discovered that CEBs are not solely determined by the physical space and activities but are also influenced by people's subjective perceptions of the environment in which the services are generated. Furthermore, our findings can be interpreted as expanding the PSD tool's application area. Instead of being primarily used to investigate the relevance of perceptual characteristics of UGSs to the stress recovery effect(Akpınar, 2021; Chen et al., 2019; Memari et al., 2021), it can now be used to investigate the correlation of environmental perceptual characteristics to the human well-beings of UGSs.

The results of the correlation analysis between various PSDs and CEB indicate that the dimensions of "Diverse," "Natural," "Serene," and "Open" have a high/moderate correlation with all CEBs. This finding is consistent with prior research on PSDs (Luo et al., 2021; Grahn and Stigsdotter, 2006; Chen et al., 2018). However, previous studies primarily examined the association between environmental perception features and psychological stress relief (Akpınar, 2021; Lockwood & Lockwood, 2017). Our study's findings can be viewed as an extension of these results, as it highlight those dimensions also associated with some other benefits, such as "sense of belongings," "social bonding," "skill improvement" and so on. The "Cultural" dimension showed weak correlations with CEBs. These findings are consistent with a previous study by Tyrväinen et al. (2007) conducted in Finland, which suggests that the capacity of green spaces to enhance human well-being is not dependent on the presence of intricate artificial elements, such as ornate fountains or manicured lawns. As a result, creating a serene, open, and natural UGSs with biodiverse landscapes may be a more effective way to enhance the CEBs of UGSs than transforming existing green spaces with numerous complicated artificial components.

Our study also found that the primary determinant of the influence of same PSD on total CEBs was the disparity between the highest perceived level within the PSD and the other levels. Conversely, we observed minimal impact on perceived CEB from the other PSD levels. Consequently, policymakers and designers should prioritize developing distinctive and exceptional features for each space in UGSs, rather than focusing on generic environmental attributes. By emphasizing these unique characteristics, the perceived levels of corresponding PSDs of UGSs may be enhanced, potentially enhancing visitors' perceived CEBs.

4.4. Limitations and suggestions for future research

Our research indicates that various PSDs can impact CEBs, but they do not provide direct guidance for UGS managers and designers in their daily activities for physical landscape elements. As PSDs are subjective and dependent on individual perception, our study did not uncover the physical landscape elements that contribute to such perceptual characteristics. Previous research has shown that the physical landscape elements have varying degrees of influence on CEBs (Baumeister et al., 2020; Brown et al., 2014; Huai et al., 2022; Oteros-Rozas et al., 2018; Zhang et al., 2022), and those different perceptions depend on physical elements and their combinations(Korpela et al., 2008; Ojala et al., 2019; Zube et al., 1982). Therefore, in future studies, researchers should address the following questions to enhance the practical implications of our findings: (i) what physical landscape elements and combinations generate different PSDs; and (ii) what is the relationship between PSDs, physical landscape elements, and CEBs?

Moreover, we recognize that our research was limited to only one urban green space in China. Given that cultural service benefits are local-based and highly subjective, we recommend that future studies include a larger and more diverse sample of urban green spaces in different geographic locations and cultural contexts. This would help to verify the generalizability of our findings and their applicability to different settings and populations.

5. Conclusion

This study used a survey-based approach to assess the CEBs and PSDs of China's largest urban national wetland park. The results indicate that preserving large green spaces in urban areas contributes to individual well-being by providing CEBs across three dimensions: identity improvement, experienced enhancement, and personal empowerment. Moreover, we developed a 15-item CEB scale that policymakers and planners can use to identify the specific CEBs that existing urban green spaces offer. When this scale is combined with other methods, such as monetary valuation, it can assist in making more informed decisions about the role of urban green spaces in comparison to other land types. Notably, this study is among the few that explore PSDs of UGSs and their perceived levels of CEBs. Our findings confirm that these PSDs and their levels influence the CEBs gained from UGSs. Therefore, landscape architects and managers can enhance the availability of specific CEBs by highlighting certain environmental characteristics that support the well-being of the rising urban population through urban green spaces.

CRediT authorship contribution statement

Mengyun Chen: Conceptualization, Methodology, Formal analysis, Writing – original draft, Visualization, Investigation. **Guangsi Lin:** Conceptualization, Supervision, Writing – review & editing, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to sincerely thank their colleagues Yue Luo, Pan Shen, Zhishan Lin, Hongli Xie, Lulu Dai, Bowen Lv, Weicheng Ye, LiBei Jiao, Qiantong Cheng, Wenxiu Chi, and Wenwen Huang at South China University of Technology for their valuable contributions to data collection. Furthermore, the authors would like to express their heartfelt gratitude to Cunxiang Fan and Zhibin Lin at Haizhu National Wetland Park for their unwavering support and invaluable assistance throughout the field research process. Additionally, the authors extend their gratitude to Chengyu Feng from the University of Science and Technology of China for the technical support provided during the construction process of the PPGIS platform. Finally, the authors are grateful to the reviewers and editors for their meticulous work and thoughtful suggestions, which have significantly enhanced the quality of this paper.

Funding

This research was funded by the National Natural Science Foundation of China, grant no. 51678242 and Guangdong Basic and Applied Basic Research Fund Guangdong Natural Science Fund, grant no. 2019A1515010483.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sufug.2023.127983.

References

Adevi, A.A., Grahn, P., 2012. Preferences for landscapes: a matter of cultural determinants or innate reflexes that point to our evolutionary background? Landsc. Res. 37 (1), 27–49. https://doi.org/10.1080/01426397.2011.576884.

Akpınar, A., 2021. How perceived sensory dimensions of urban green spaces are associated with teenagers' perceived restoration, stress, and mental health? Landsc. Urban Plan. 214, 104185 https://doi.org/10.1016/J.LANDURBPLAN.2021.104185.

Alessa, L. (Naia), Kliskey, A. (Anaru), Brown, G., 2008. Social–ecological hotspots mapping: A spatial approach for identifying coupled social–ecological space. . Q1 Landsc. Urban Plan. 85 (1), 27–39. https://doi.org/10.1016/j.landurbplan.2007.09.007.

Andersson, E., Tengö, M., McPhearson, T., Kremer, P., 2015. Cultural ecosystem services as a gateway for improving urban sustainability. Ecosyst. Serv. 12, 165–168. https://doi.org/10.1016/j.ecoser.2014.08.002.

Baard, P., 2019. The goodness of means: instrumental and relational values, causation, and environmental policies. J. Agric. Environ. Ethics 32 (1), 183–199. https://doi.org/10.1007/s10806-019-09762-7.

Baumeister, C.F., Gerstenberg, T., Plieninger, T., Schraml, U., 2020. Exploring cultural ecosystem service hotspots: Linking multiple urban forest features with public participation mapping data. Urban For. Urban Green. 48, 126561 https://doi.org/10.1016/J.UFUG.2019.126561.

Bieling, C., Plieninger, T., Pirker, H., Vogl, C.R., 2014. Linkages between landscapes and human well-being: An empirical exploration with short interviews. Ecol. Econ. 105, 19–30. https://doi.org/10.1016/J.ECOLECON.2014.05.013.

Blicharska, M., Smithers, R.J., Hedblom, M., Hedenås, H., Mikusiński, G., Pedersen, E., Sandström, P., Svensson, J., 2017. Shades of grey challenge practical application of the cultural ecosystem services concept. Ecosyst. Serv. 23. https://doi.org/10.1016/j.ecoser.2016.11.014.

Brazier, J., Roberts, J., Deverill, M., 2002. The estimation of a preference-based measure of health from the SF-36. J. Health Econ. 21 (2), 271–292. https://doi.org/10.1016/S0167-6296(01)00130-8.

Brown, G., 2013. The relationship between social values for ecosystem services and global land cover: An empirical analysis. Ecosyst. Serv. 5, 58–68. https://doi.org/10.1016/j.ecoser.2013.06.004.

Brown, G., Kyttä, M., 2014. Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. Q1. Appl. Geogr. 46, 122–136. https://doi.org/10.1016/j.apgeog.2013.11.004.

Brown, G., Montag, J.M., Lyon, K., 2012. Public participation GIS: a method for identifying ecosystem services. Q2/Q3 Soc. Nat. Resour. 25 (7), 633–651. https://doi.org/10.1080/08941920.2011.621511.

Brown, G., Rhodes, J., Dade, M., 2018. An evaluation of participatory mapping methods to assess urban park benefits. Landsc. Urban Plan. 178. https://doi.org/10.1016/j.landurbplan.2018.05.018.

Brown, G., Schebella, M.F., Weber, D., 2014. Using participatory GIS to measure physical activity and urban park benefits. Landsc. Urban Plan. 121. https://doi.org/10.1016/j.landurbplan.2013.09.006.

Bryce, R., Irvine, K.N., Church, A., Fish, R., Ranger, S., Kenter, J.O., 2016. Subjective well-being indicators for large-scale assessment of cultural ecosystem services. Ecosyst. Serv. 21, 258–269. https://doi.org/10.1016/j.ecoser.2016.07.015.

Cai, K., Huang, W., Lin, G., 2022. Bridging landscape preference and landscape design: A study on the preference and optimal combination of landscape elements based on conjoint analysis. Urban For. Urban Green. 73, 127615 https://doi.org/10.1016/J.UFUG.2022.127615.

Chan, K.M.A., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. Ecol. Econ. 74, 8–18. https://doi.org/10.1016/J.ECOLECON.2011.11.011.

Chen, H., Qiu, L., Gao, T., 2019. Application of the eight perceived sensory dimensions as a tool for urban green space assessment and planning in China. Urban For. Urban Green. 40. https://doi.org/10.1016/j.ufug.2018.10.001.

Cheng, X., Damme, S.V., Uyttenhove, P., 2021. A review of empirical studies of cultural ecosystem services in urban green infrastructure. J. Environ. Manag. 293, 112895 https://doi.org/10.1016/j.jenvman.2021.112895.

Church, A., Fish, R., Haines-Young, R., Mourato, S., Tratalos, J.A., Stapleton, L.M., Willis, C., Coates, P., Gibbons, S., Leyshon, C., Potschin, M., Ravenscroft, N., Sanchis-Guarner, R., Winter, M., & Kenter, J.O. (2021). UK National Ecosystem Assessment follow-on: Work package report 5: Cultural ecosystem services and indicators. ⟨https://uobrep.openrepository.com/handle/10547/625182⟩.

Clarke, B., Thet, A.K., Sandhu, H., Dittmann, S., 2021. Integrating Cultural Ecosystem Services valuation into coastal wetlands restoration: A case study from South Australia. . Q1 Environ. Sci. Policy 116, 220–229. https://doi.org/10.1016/j.envsci.2020.11.014.

Collins, C., Haase, D., Heiland, S., Kabisch, N., 2022. Urban green space interaction and wellbeing – investigating the experience of international students in Berlin during the first COVID-19 lockdown. Q1 Urban For. Urban Green. 70, 127543. https://doi.org/10.1016/j.ufug.2022.127543.

Cooper, N., Brady, E., Steen, H., Bryce, R., 2016. Aesthetic and spiritual values of ecosystems: Recognising the ontological and axiological plurality of cultural ecosystem 'services'. . Q1 Ecosyst. Serv. 21, 218–229. https://doi.org/10.1016/j.ecoser.2016.07.014.

Dade, M.C., Mitchell, M.G.E., Brown, G., Rhodes, J.R., 2020. The effects of urban greenspace characteristics and socio-demographics vary among cultural ecosystem services. Urban For. Urban Green. 49, 126641 https://doi.org/10.1016/J.UFUG.2020.126641.

Dahiya, B., 2012. Cities in Asia, 2012: Demographics, economics, poverty, environment and governance. Cities 29 (SUPPL.2). https://doi.org/10.1016/j.cities.2012.06.013.

De Vries, S., Buijs, A.E., Langers, F., Farjon, H., van Hinsberg, A., Sijtsma, F.J., 2013. Measuring the attractiveness of Dutch landscapes: Identifying national hotspots of highly valued places using Google Maps. Q1. Appl. Geogr. 45, 220–229. https://doi.org/10.1016/j.apgeog.2013.09.017.

Dickinson, D.C., Hobbs, R.J., 2017. Cultural ecosystem services: Characteristics, challenges and lessons for urban green space research. Ecosyst. Serv. 25 https://doi.org/10.1016/j.ecoser.2017.04.014.

Dzhambov, A., Hartig, T., Markevych, I., Tilov, B., Dimitrova, D., 2018. Urban residential greenspace and mental health in youth: Different approaches to testing multiple pathways yield different conclusions. Environ. Res. 160, 47–59. https://doi.org/10.1016/J.ENVRES.2017.09.015.

Ecosystems and Human Well-being: Synthesis. Millennium Ecosystem Assessment Island Press, Washington, DC, USA (2005).

Edwards, D.M., Collins, T.M., Goto, R., 2016. An arts-led dialogue to elicit shared, plural and cultural values of ecosystems. . Q1 Ecosyst. Serv. 21, 319–328. https://doi.org/10.1016/j.ecoser.2016.09.018.

Egoh, B., Reyers, B., Rouget, M., Richardson, D.M., Le, D.C., Jaarsveld, A.S.V., 2008. Agriculture, Ecosystems and Environment Mapping ecosystem services for planning and management. Agric., Ecosyst. Environ. 127, 135–140.

Fish, R., Church, A., Winter, M., 2016. Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. Ecosyst. Serv. 21 https://doi.org/10.1016/j.ecoser.2016.09.002.

Fish, R., Church, A., Willis, C., Winter, M., Tratalos, J.A., Haines-Young, R., Potschin, M., 2016. Making space for cultural ecosystem services: Insights from a study of the UK nature improvement initiative. . Q1 Ecosyst. Serv. 21, 329–343. https://doi.org/10.1016/j.ecoser.2016.09.017.

Folke, C., Jansson, Å., Rockström, J., Olsson, P., Carpenter, S.R., Stuart Chapin, F., Westley, F., 2011. Reconnecting to the biosphere. Ambio Vol. 40, 719–738. https://doi.org/10.1007/s13280-011-0184-y.s.

Franco, L.S., Shanahan, D.F., Fuller, R.A., 2017. A review of the benefits of nature experiences: More than meets the eye. International Journal of Environmental Research and Public Health. MDPI. https://doi.org/10.3390/ijerph14080864.

Grahn, P., 1991. Landscapes in our minds: People's choice of recreative places in towns. Landsc. Res. 16 (1), 11–19. https://doi.org/10.1080/01426399108706326.

Grahn, P., Stigsdotter, U.K., 2010. The relation between perceived sensory dimensions of urban green space and stress restoration. Landsc. Urban Plan. 94 (3–4), 264–275. https://doi.org/10.1016/j.landurbplan.2009.10.012.

Huai, S., Chen, F., Liu, S., Canters, F., de Voorde, T.V., 2022. Using social media photos and computer vision to assess cultural ecosystem services and landscape features in urban parks. Ecosyst. Serv. 57, 101475 https://doi.org/10.1016/J.ECOSER.2022.101475.

Jabbar, M., Yusoff, M.M., Shafie, A., 2022. Assessing the role of urban green spaces for human well-being: A systematic review. GeoJournal 87 (5), 4405–4423. https://doi.org/10.1007/s10708-021-10474-7.

Kenter, J.O., Bryce, R., Christie, M., Cooper, N., Hockley, N., Irvine, K.N., Fazey, I., O'Brien, L., Orchard-Webb, J., Ravenscroft, N., Raymond, C.M., Reed, M.S., Tett, P., Watson, V., 2016. Shared values and deliberative valuation: Future directions. . Q1 Ecosyst. Serv. 21, 358–371. https://doi.org/10.1016/j.ecoser.2016.10.006.

Klain, S.C., Satterfield, T.A., Chan, K.M.A., 2014. What matters and why? Ecosystem services and their bundled qualities. Ecol. Econ. 107, 310–320. https://doi.org/10.1016/j.ecolecon.2014.09.003.

Korpela, K.M., Ylén, M., Tyrväinen, L., Silvennoinen, H., 2008. Determinants of restorative experiences in everyday favorite places. . Q1/Q2 Health Place 14 (4), 636–652. https://doi.org/10.1016/j.healthplace.2007.10.008.

Kyle, G., Graefe, A., Manning, R., 2005. Testing the Dimensionality of Place Attachment in Recreational Settings. . Q1 Environ. Behav. 37 (2), 153–177. https://doi.org/10.1177/0013916504269654.

La Rosa, D., Spyra, M., Inostroza, L., 2016. Indicators of Cultural Ecosystem Services for urban planning: A review. . Q1 Ecol. Indic. 61, 74–89. https://doi.org/10.1016/j.ecolind.2015.04.028.

Lockwood, A.L. (2017). Balancing Perceived Sensory Dimensions and Biotopes in Urban Green Space Design. ⟨http://hdl.handle.net/10214/10432⟩.

Lopez, B., Kennedy, C., Field, C., McPhearson, T., 2021. Who benefits from urban green spaces during times of crisis? Perception and use of urban green spaces in New York City during the COVID-19 pandemic. Q1. Urban For. Urban Green. 65, 127354 https://doi.org/10.1016/j.ufug.2021.127354.

Memari, S., Pazhouhanfar, M., Grahn, P., 2021. Perceived sensory dimensions of green areas: an experimental study on stress recovery. Article 10 Sustainability 13 (10). https://doi.org/10.3390/su13105419.

Meyer-Grandbastien, A., Burel, F., Hellier, E., Bergerot, B., 2020. A step towards understanding the relationship between species diversity and psychological restoration of visitors in urban green spaces using landscape heterogeneity. Q1. Landsc. Urban Plan. 195, 103728 https://doi.org/10.1016/j.landurbplan.2019.103728.

Michaelis, A.K., Walton, W.C., Webster, D.W., Shaffer, L.J., 2021. Cultural ecosystem services enabled through work with shellfish. . Q1/Q2 Mar. Policy 132, 104689. https://doi.org/10.1016/j.marpol.2021.104689.

Nowak-Olejnik, A., Schirpke, U., Tappeiner, U., 2022. A systematic review on subjective well-being benefits associated with cultural ecosystem services. Ecosyst. Serv. 57, 101467 https://doi.org/10.1016/J.ECOSER.2022.101467.

O'Brien, L., De Vreese, R., Kern, M., Sievänen, T., Stojanova, B., Atmiş, E., 2017. Cultural ecosystem benefits of urban and peri-urban green infrastructure across different European countries. . Q1 Urban For. Urban Green. 24, 236–248. https://doi.org/10.1016/j.ufug.2017.03.002.

Ojala, A., Korpela, K., Tyrväinen, L., Tiittanen, P., Lanki, T., 2019. Restorative effects of urban green environments and the role of urban-nature orientedness and noise sensitivity: A field experiment. . Q1/Q2 Health Place 55, 59–70. https://doi.org/10.1016/j.healthplace.2018.11.004.

Oteros-Rozas, E., Martín-López, B., Fagerholm, N., Bieling, C., Plieninger, T., 2018. Using social media photos to explore the relation between cultural ecosystem services and landscape features across five European sites. Ecol. Indic. 94, 74–86. https://doi.org/10.1016/J.ECOLIND.2017.02.009.

Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. . Q1 Land Use Policy 33, 118–129. https://doi.org/10.1016/J.LANDUSEPOL.2012.12.013.

Pocewicz, A., Nielsen-Pincus, M., Brown, G., Schnitzer, R., 2012. An evaluation of internet versus paper-based methods for Public Participation Geographic Information Systems (PPGIS). Trans. GIS 16 (1), 39–53. https://doi.org/10.1111/j.1467-9671.2011.01287.x.

Rall, E., Bieling, C., Zytynska, S., Haase, D., 2017. Exploring city-wide patterns of cultural ecosystem service perceptions and use. . Q1 Ecol. Indic. 77, 80–95. https://doi.org/10.1016/j.ecolind.2017.02.001.

Ramirez Aranda, N., De Waegemaeker, J., Van de Weghe, N., 2023. Cultural ecosystem services along the Woluwe River: Mapping the potential for a cross-regional green-blue network during the COVID-19 pandemic. . Q2/Q3 J. Environ. Plan. Manag. 0 (0), 1–27. https://doi.org/10.1080/09640568.2023.2177141.

Sherrouse, B.C., Clement, J.M., Semmens, D.J., 2011. A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. . Q1 Appl. Geogr. 31 (2), 748–760. https://doi.org/10.1016/j.apgeog.2010.08.002.

Stoltz, J., Grahn, P., 2021. Perceived sensory dimensions: An evidence-based approach to greenspace aesthetics. Urban For. Urban Green. 59. https://doi.org/10.1016/j.ufug.2021.126989.

Tyrväinen, L., Mäkinen, K., Schipperijn, J., 2007. Tools for mapping social values of urban woodlands and other green areas. Landsc. Urban Plan. 79 (1), 5–19. https://doi.org/10.1016/j.landurbplan.2006.03.003.

Xin, C., Sylvie, V.D., Luyuan, L., Pieter, U., 2020. Taking "social relations" as a cultural ecosystem service: A triangulation approach. Urban For. Urban Green. 55. https://doi.org/10.1016/j.ufug.2020.126790.

Xu, H., Zhao, G., Fagerholm, N., Primdahl, J., Plieninger, T., 2020. Participatory mapping of cultural ecosystem services for landscape corridor planning: A case study of the Silk Roads corridor in Zhangye, China. J. Environ. Manag. 264, 110458 https://doi.org/10.1016/J.JENVMAN.2020.110458.

Zhang, K., Tang, X., Zhao, Y., Huang, B., Huang, L., Liu, M., Luo, E., Li, Y., Jiang, T., Zhang, L., Wang, Y., Wan, J., 2022. Differing perceptions of the youth and the elderly regarding cultural ecosystem services in urban parks: An exploration of the tour experience. Sci. Total Environ. 821, 153388 https://doi.org/10.1016/j.scitotenv.2022.153388.

Zoeller, K.C., Gurney, G.G., Cumming, G.S., 2022. The influence of landscape context on the production of cultural ecosystem services. Landsc. Ecol. 37 (3), 883–894. https://doi.org/10.1007/s10980-022-01412-0.

Zube, E.H., Sell, J.L., Taylor, J.G., 1982. Landscape perception: Research, application and theory. Landsc. Plan. 9 (1), 1–33. https://doi.org/10.1016/0304-3924(82)90009-0.